Design and Analysis of Composite Drive Shaft for Automotive Application

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***Abstract*— This paper examines the result of fiber orientation angles and stacking sequence on the torsional stiffness, natural frequency and buckling strength of composite drive shaft. The weight reduction of the drive shaft can have a certain role in the general weight reduction of the vehicle and is a highly desirable goal. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. The advanced composite materials such as graphite, carbon, Kevlar and Glass fibers with suitable resins are widely used because of their high specific strength and high specific modulus. The automotive industry is exploiting composite material technology for structural components construction in order to obtain the reduction of the weight without decrease in vehicle functional quality and reliability. It is known that energy conservation is one of the most important objectives in vehicle design and reduction of weight is one of the most effective measures to obtain this result. Actually, there is almost a direct proportionality between the weight of a vehicle and its fuel consumption, particularly in city driving. In the present work an attempt is made to evaluate the suitability of composite material for the purpose of automotive transmission applications. A composite drive shaft is optimally analyzed using ANSYS for hybrid of high strength carbon fiber, high modulus carbon fiber and Kevlar fiber with Epoxy resin composites with the objective of minimization of weight of the shaft which is subjected to the constraints such as torque transmission, tensional and buckling strength capabilities. The present work includes analysis on drive shaft of Indian car with composite material and concludes that the use of composite materials for drive shaft would induce less amount of stress which additionally reduces the weight of the shaft.**

Keywords*— *Drive shaft; composite;weight reduction; ansys.

I. INTRODUCTION

A driveshaft is a rotating shaft that transmits drive to wheels. Driveshaft must operate through constantly changing angles between the transmission and axle. High quality steel (Steel SM45) is a common material for construction. Power transmission can be improved through the reduction of inertial mass and light Hook's weight. In the design of metallic shaft, knowing the torque and the allowable shear stress for the material, the size of the shaft's cross section can be determined. Nowadays there is a heavy requirement for lightweight materials in automotives. The conventional steel material is replaceable by advanced composite materials. Composite materials are favored by most of the scientist in the design of automobiles due to its higher specific strength and stiffness. Composite materials can be tailored to efficiently meet the design requirements of strength, stiffness and composite drive shafts weightless than steel or aluminum of similar strength. Also, composite materials typically have lower modulus of elasticity. As a result, when torque peaks occur in the driveline, the driveshaft can act as a shock absorber and decrease stress on part of the drive train extending life. Many researchers have been investigated about hybrid drive shafts and joining methods of the hybrid shafts to the yokes of universal Joints. But this project provides the analysis of the design in many aspects.

Composite materials are commonly used in structures that demand a high level of mechanical performance. Their high strength to weight and stiffness to weight ratios has facilitated the development of lighter structures, which often replace conventional metal structures. Rapid technological advances in engineering design field result in finding the alternate solution for the conventional materials. The design engineers brought to a point to finding the materials which are more reliable than conventional materials. Drive shafts are used as power transmission tubing in many applications, including cooling towers, pumping sets, aerospace, trucks and automobiles. Drive shafts are usually made of solid or hollow tube of steel or aluminum. Over than 70% of single or two-piece differentials are made of several piece propeller shaft that result in a rather heavy drive shaft Composite drive shafts were begun to be used in bulk in automotives since 1988.

The graphite/carbon/fiberglass/aluminum driveshaft tube was developed as a direct response to industry demand for greater performance and efficiency in light trucks, vans and high performance automobiles. The main reason for this was significant saving in weight of drive shaft; the results showed that the final composite drive shaft has a mass of about 2.7 kg, while this amount for steel drive shaft is about10 kg. The use of composite drive shafts in race cars has gained great attention in recent decades. When a steel drive shaft breaks, its components, are thrown in all directions such as balls, it is also possible that the drive shaft makes a hole in the ground and throw the car into the air. But when a composite drive shaft breaks, it is divided into fine fibers that do not have any danger for the driver. Numerous studies have been carried out to investigate the optimal design and analysis of composite drive shafts with different materials and layers orientation. M.A. Badie, E. Mahdi , A.M.S. Hamouda investigated the effect of fiber orientation angles and stacking sequence on the torsional stiffness, natural frequency, buckling strength, fatigue life and failure modes of composite tubes. by this investigation they found that critical buckling torque has a peak value at 90° and lowest at a range of 20°–40° when the angle of one or two layers in a hybrid or all layers. Composite tubes of fiber orientation angles of ±45° experience higher load carrying capacity and higher torsional stiffness. Fibers must be oriented at 0° to increase the natural frequency by increasing the modulus of elasticity in the longitudinal direction of the shaft. The configuration [0°, 0°, 90°, 0°] results in the highest natural frequency . Critical speeds for all models are the same when the fibers of all layers oriented at 38°–90° The stacking sequence has no effect on the natural frequency, because the matrix form of the equation of dynamic equilibrium of elastic body only contain stiffness and mass matrices when no damping and external forces applied The best fiber orientation angle for maximum buckling strength is 90° At this angle the fibers oriented in the hoop the modulus Ex has its maximum value at 0°fiber orientation angle and the modulus Eh has its maximum value at 90° angle direction Since the expression of buckling torque if related to both moduli, then the peak value for this torque realized when the fibers oriented at 0° and 90°. While designing for fatigue consideration, the layers of ±45° fiber orientation must kept close to each other and have a location near to inner surface not to be exposed at outer surface. Static failure torque of 45° fibers orientation is higher than 90°.The bending natural frequency increase by decreasing the fiber orientation angle. Decreasing the angle increase the modulus in the axial direction. The layers stacking sequence has no effect on the natural frequency since there is no load applied. Fiber orientation angle has an effect on the buckling torque. Stacking sequence has a big effect on the buckling torque. The stacking sequence has an effect on the fatigue resistance. The best stacking is to locate the layers of ±45° fiber orientation angles together and far near the inner face of the torque tube. In addition, the cross-ply configuration must be located exposed to outside with the seniority of the 90° layer at the outer face location. Carbon fibers have the major contribution over glass in increasing the torsional stiffness. The fiber orientation angle of 45° is the best in increasing the torsional stiffness. Laminates containing fabric fibers placed at ±45° experienced sudden failure whatever the material is. On the other hand, the stacking of 90°/0° experienced a progressive and gradual failure. Carbon/epoxy tubes experience higher fracture strain than that of glass/epoxy [1].

A.R. Abu Talib, Aidy Ali, Mohamed A. Badie , Nur Azida Che Lah, A.F. Golestaneh investigated about hybrid, carbon/glass fiber-reinforced, epoxy composite automotive drive shaft. They found that changing carbon fibers winding angle from 0° to 90°, the loss in the natural frequency of the shaft is 44.5%, while, shifting from the best to the worst stacking sequence, the drive shaft causes a loss of 46.07% in its buckling strength. The best fiber orientation angle for maximum buckling strength is 90°. Natural frequency is maximum at 0° and decreases as the fiber angle shifts towards 90° [2].

Shaw D, Simitses DJ, Sheinman I investigated about Imperfection sensitivity of laminated cylindrical shells in torsion and axial compression. They found that the linear analysis is considered satisfactory in comparison with nonlinear analysis due to the fact that cylindrical shells under torsion are less sensitive to imperfections [3].

H.B.H. Gubran investigated about Dynamics of hybrid shafts and he found that Depending on E1/q ratio for metals and fiber angle for composites, the natural frequencies of hybrid shafts can be optimally placed [4].

Ercan Sevkat, Hikmet Tumer, investigated about Residual torsional properties of composite shafts subjected to impact Loadings. They found that the Carbon reinforced composite shaft had the highest; glass reinforced composite had the lowest resistance to impact. Resistance of hybrid composite shafts was between that of glass and carbon [5].

H. Bayrakceken, S. Tasgetiren, I. Yavuz, investigated about two cases of failure in the power transmission system on vehicles: A universal joint yoke and a drive shaft, they concluded that failures are occurred as a result of fatigue process [6].

R. Srinivasa Moorthy, Yonas Mitiku & K. Sridhar investigated about Design of Automobile Driveshaft using Carbon/Epoxy and Kevlar/Epoxy Composites. They found that use of Carbon/Epoxy results in a mass saving of 89.756% when compared to the conventional SM45C steel driveshaft, whereas Kevlar/Epoxy results in 72.53%. Obviously, the number of plies needed for Carbon/Epoxy is 14 with 1.82 mm wall thickness as compared to 44 plies with 5.72 mm wall thickness in the case of Kevlar/Epoxy. Moreover, the torsional buckling capacity and bending natural frequency are adequate enough to meet the design requirements in the case of Carbon/Epoxy driveshaft [7].

Harshal Bankar, Viraj Shinde, P.Baskar investigated about Material Optimization and Weight Reduction of Drive Shaft Using Composite Material. They found that Young's modulus in the X direction is higher for smaller ply angle and suddenly falls down above the 25 degrees. But in the case of Y direction constant at lower ply angle and suddenly increase above 70degrees.Also the shear modulus has maximum value for the ply in between the 30 to 70 degrees. The shaft is subjected under both the types of load normal and shear. To optimize these two conditions it need to select the equal no of ply angles for Young's and shear modulus. Reduction in the weight of shaft increases the 1st modal frequency of bending; hence the composite shaft can be utilized for higher frequencies than the steel [8].

Ali S. Hammood, Muhannad Al-Waily, Ali Abd. Kamaz investigated about Effect of fiber orientation on fatigue of glass-fiber reinforcement epoxy composite material they found that fatigue strength of composite material decreasing with increasing the fiber orientation angle due to decreasing module of elasticity (strength) of composite materials. Number of fatigue cycle decreasing with increasing the fiber orientation angle, maximum at fiber angle (0^o) and minimum at fiber angle (90^o). The magnitude of fatigue strength and number of cycle of fatigue for composite material are decreasing with increasing fiber orientation angle, increasing with increasing the strength of composite material and decreasing with decreasing the strength of composite materials. For oblique load on fiber direction, the surface fatigue of composite materials parallel of fiber direction and for unidirectional fiber, surface fatigue perpendicular on fiber direction [9].

Ban. Bakir and Haithem . Hashem investigated about Effect of Fiber Orientation for Fiber Glass Reinforced Composite Material on Mechanical Properties they found that the effect on hardness of the materials having different orientations of fiber and it is maximum in discontinuous fiber specimen, with orientation 90°, with orientation 0°, then with orientation 45° respectively impact strength is minimum in orientation 90° and above of that in parallel orientation and still constant in specimen of angle 45 °. It has been observed that the crack propagates in a direction perpendicular to the direction of the external load action glass fibers/epoxy composite specimens of 90° fiber orientation angle, while for 0° fiber orientation angle of glass fibers/ epoxy specimens, failure was irregular and cracks propagate in different directions [10].

B Stanly Jones Retnam, M Sivapragash and P Pradeep investigated about Effects of fiber orientation on mechanical properties of hybrid bamboo/glass fiber polymer composites they concluded that the hybrid specimen with $\pm45^o$ orientation yielded a tensile strength of 92.26 N/mm2, flexural strength of

387.725 N/mm2 and which was higher when compared with others. The hybrid specimen with $\pm45^o$ orientation posses a flexural strength of 387.725 N/mm2 impact strength of 87 KJ/m2 which was higher when compared with others. The Hardness test reveals that the hybrid specimen with $0^o/90^o$orientation shows a Hardness number of 62.3 HR. $\pm45^o$ orientation helps to boost up the mechanical properties of the composites [11].

K.Vasantha Kumar, Dr.P.Ram Reddy, Dr.D.V.Ravi Shankar investigated about Effect of Angle Ply Orientation On Tensile Properties Of Bi Directional Woven Fabric Glass Epoxy Composite Laminate, they concluded that glass/Epoxy with 0^ofiber orientation Yields' high strength when compare to other degree of orientations for the same load, size & shape In addition glass/epoxy with 0^oorientation have higher strength, stiffness and load carrying capacity than any other orientation [12].

R. Sino,T.N. Baranger,E. Chatelet,G. Jacquet investigated about Dynamic analysis of a rotating composite shaft they concluded that closer the fiber is oriented to 90^o,the greater the internal damping and the sooner instability may appear. Equivalent rigidity decreases as a function of ply angle, whereas, the damped equivalent rigidity increases [13].

D.G. Lee, N.P. Suh. Axiomatic design and fabrication of composite structures: Applications in robots, machine tools, and automobiles they concluded that Since the fiber volume of 60% is the standard fiber volume fraction for most industries, it was selected for composite drive shaft.[14].

N. Rastogi investigated about Design of composite drive shafts for automotive applications he concluded that Among the various laminate configurations, [±45] laminates possess the highest shear modulus and are the primary laminate type used in purely torsional applications [15].

Mr. V.l.Narayana1 Mr. D.Mojeswararao Mr. M.N.V.R.L.Kumar investigated about Material optimization of composite drive shaft assembly in comparison with conventional steel drive shaft. They concluded that E-CARBON can be used instead of conventional material like structural steel. So that the weight and stresses induced in the drive shaft can be considerably decreased [16].

M.Arun, K.Somasundara Vinoth investigated about Design and Development of Laminated Aluminum Glass Fiber Drive Shaft for Light Duty Vehicles and they concluded that increasing the number of composite layers would increase the fatigue strength for a hybrid aluminum/composite drive shaft. Increasing the number of layers would enhance the maximum static torsion approximately 66% for [+45/-45] laminates [17].

Madhu K.S., Darshan B.H. Manjunath K Investigated about buckling analysis of composite drive shaft for automotive applications. They found that Kevlar/Epoxy and HM Carbon/ Epoxy shafts are good in shear strength and bending natural frequency and are excellent from vibration point of view [18].

Amol S. BhanageȦ, Vijay B. PatilȦ and Rajat S. PatilȦ investigated about A Review: Finite Element Simulation of Automotive Drive Shaft Using Composite Materials they found that the drive shaft buckled when it's bending stiffness along the hoop direction can't support the applied torsion load. Effect of stacking sequence on the buckling strength shows that best stacking sequence is [45º/-45º/0º/90º] with a normal bending stiffness and worst stacking is [0º/90º/-45º/45º] [19].

II. MODELLING

drive shaft the following assumptions are considered in ansys. The assumptions are, the shaft rotates at a constant speed about its longitudinal axis. The shaft has a uniform, circular cross section. The shaft is perfectly balanced, all damping and nonlinear effects are excluded. The stress-strain relationship for composite material is linear and elastic; hence, Hook's law is applicable for composite materials. Since lamina is thin and no out-of-plane loads are applied, it is considered as under the plane stress. High strength carbon fiber, high modulus carbon fibers and Kevlar fibers are used as reinforcement in the form of uni directional fabric and epoxy with catalyst addition as matrix for the composite material.

The material properties are presented in the below table

TABLE-2.1

Symbol	Unit	HSC	HMC	Kevlar
E1	GPa	135	85	75
E2	GPa	10	85	6
G12	GPa	5	5	2
V12	-	0.3	0.1	0.34
ρ	Kg/m³	1600	1600	1400

A. Lay-Up Selection

Type of ply orientation influences the different type of properties in fiber reinforced composites based on the literature review we have listed the specific characteristics of major types of ply orientations.

B. Zero Degree Orientation

Zero degree Orientation can be used as better choice for composite application because of having below mentioned properties.

- Superior natural frequency value
- Superior impact strength

It must be oriented inner and outer layers to increase the natural frequency

C. 45 Degree Orientation

This orientation has an effect on the below properties of composite shaft. It may be better from the other orientation

- Superior shear strength
- Superior fatigue strength
- High impact strength
- High load carrying capacity
- High torsional stiffness
- Low modulus in axial direction
- Primary laminate for torsional application

For better fatigue strength +/-45deg should be located at inner surface and 0/90deg should be located at outer surface

D. 90deg orientation

90 degree Orientation was also deserves some acceptable properties for composites. Those properties are mentioned below.

- Superior tensile strength
- Superior flexural strength
- Superior critical buckling torque
- High stiffness
- High load carrying capacity

Based on the above considerations three sets of symmetrical Laminates with a total of twenty five layers each are produced:

- Set1: [0/-40/+40/90/0]
- Set2: [0/+45/-45/90/0]
- Set3: [0/+50/-50/90/0]

The numbers mentioned in the above sets indicates the angle of ply inclination measured by degrees. A typical specimen made from fiber reinforced plastic (FRP) composite shaft formed from twenty five plies with 0.00046mm thickness for each ply. Shell 99 element was used to model the drive shaft. It usually has a smaller element formulation time. SHELL99 allows up to 250 layers. If more than 250 layers are required, a user-input constitutive matrix is available.

Assumptions and Restrictions in shell99 element:

- Zero area elements are not allowed.
- Zero thickness layers or layers tapering down to a zero thickness at any corner are not allowed.
- No slippage is assumed between the element layers.
- Shear deflections are included in the element, however, normals to the center plane before deformation are assumed to remain straight after deformation.
- The stress varies linearly through the thickness of each layer.
- Inter laminar transverse shear stresses are based on the assumption that no shear is carried at the top and bottom surfaces of an element.

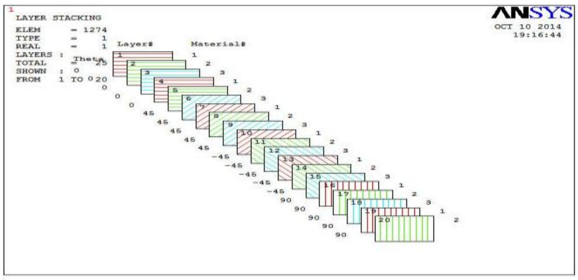

Fig: 2.1 layer sequence of composites drive shaft

III. FINITE ELEMENT ANALYSIS

The finite element analysis is a numerical technique for finding approximate solutions of partial differential equations as well as of integral equations. The solution approach is based on either eliminating the differential equation completely (steady state problems) or rendering the partial differential equation into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's method, Runge - Kutta method etc., In the finite element method, a structure is broken down into many small simple blocks or elements. The behavior of an individual element can be described with a relatively simple set of equations. Just as the set of elements would be joined together to build the whole structure, the equations describing the behaviors of the individual elements are joined into an extremely large set of equations that describe the behavior of the whole structure. The commercial FEA software ANASYS 12 was used to model the entire of the composite drive shaft. The 3-D model was developed and a typical meshing was generated by using Shell 99 element.

The following steps summarize the general procedure for finite element analysis.

Step 1:

The continuum is a physical body, structure or solid being analyzed. Discretization may be simply described as process by which the given body is subdivided into equivalent system of finite elements.

Step 2:

The selection of displacement or temperature models representing approximately, the actual distribution in the displacement or temperature. The three factors which influence the selection of shape functions are,

- The type and degree of displacement model
- Displacement magnitudes
- The requirements to be satisfied which ensuring correct solution.

Step 3:

The derivation of the stiffness matrix which consists of the coefficients of the equilibrium equations derived from the geometric and material properties of the element. The stiffness relates the displacement at nodal points to applied forces at nodal points.

Step 4:

Assembly of the algebraic equations for the overall discredited continuum includes the assembly of overall stiffness matrix for the entire body from individual element stiffness matrices and the overall global load vector from the elemental load vectors.

Step 5:

The algebraic equations assembled in step 4 are solved for unknown displacements by imposing the boundary conditions. In linear equilibrium problems, this is a relatively straightforward application of matrix algebra techniques.

Step 6:

In this step, the element strains and stresses are computed from the nodal displacements that are already calculated from step 5.

A. Meshing:

The meshing is the method in which the geometry is divided into small number of elements. We have selected area mesh for the meshing with the element size of 4, which will provide us fine meshing. Also we have selected quadrilateral mesh element for accurate and uniform meshing of component.

B. Loading and boundary conditions:

One end of the drive shaft was fixed at all six degrees of freedom and the torque of 114NM was applied at other end with positive ``z`` direction.

C. Static analysis:

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those carried by time varying loads. A static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects. A static analysis can however include steady inertia loads such as gravity, spinning and time varying loads. If these values exceeds above the allowable values then component is going to fail. Hence static analysis is necessary while analyzing the drive shaft.

D. Torsional analysis:

The boundary condition for the torsional analysis of drive shaft are given as the one end is constrained with zero displacement in the both linear and rotational. At the other end of shaft torque is applied. The purpose of the drive shaft is to transmit the power from engine output to the wheel so the torque carrying capacity must be analyzed in order to find out the toque carrying capacity of the composite drive shaft.

E. Modal Analysis:

The modal analysis is one of the important analysis for drive shaft The modal analysis is required as the 1st mode frequency of vibration must be less than shaft operating frequency to avoid failure of drive shaft.

F. Buckling analysis:

The objective of buckling analysis is to obtain critical buckling load. In buckling analysis the model was fully fixed in all six degrees of freedom at one end and subjected to torsion load at other end.

IV. RESULT AND DISCUSSION

STATIC ANALYSIS

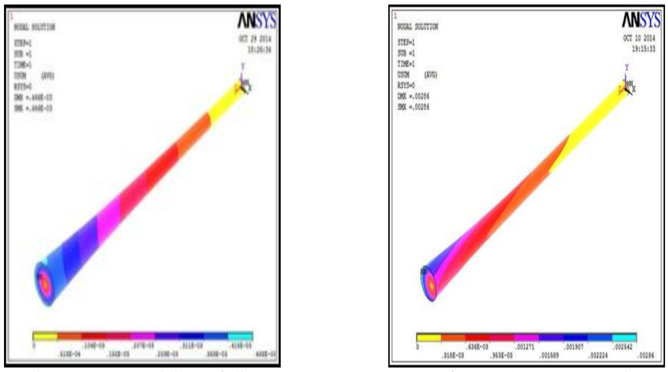

Fig 4.1 Comparision of displacement vector sum for steel and composite

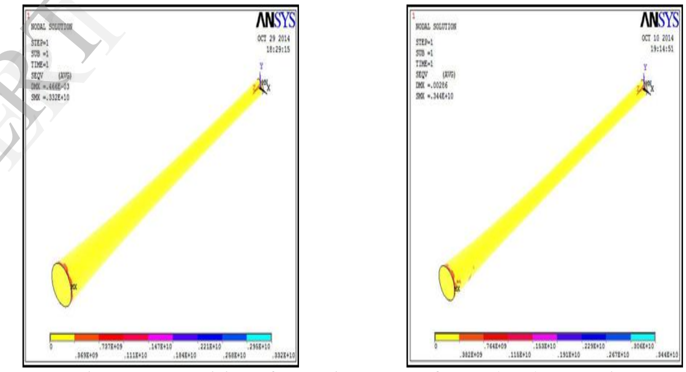

Fig 4.2 Comparision of von misses stress for steel and composite

BUCKLING ANALYSIS

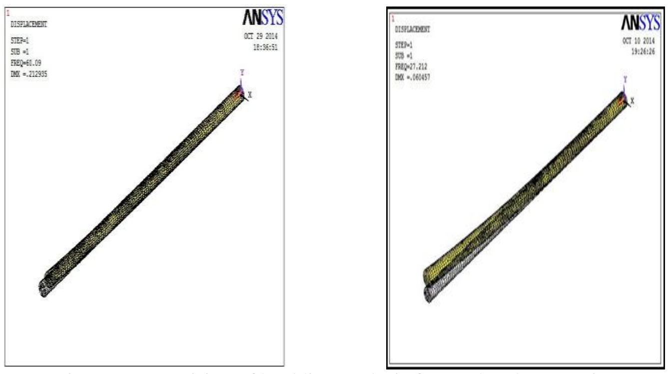

Fig 4.3 Comparision of buckling analysis for steel and composite

MODEL ANALYSIS

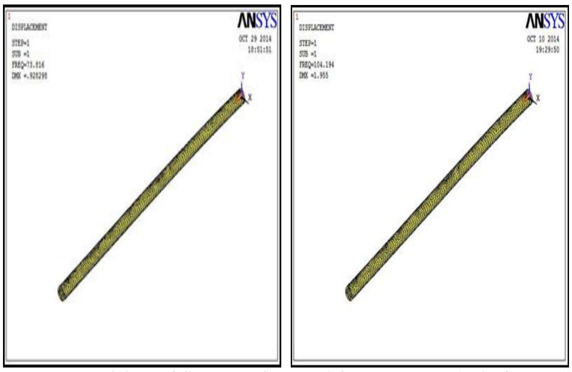

Fig 4.4 Comparision of first set of natural frequency analysis for steel and composite

Fig 4.4 Comparision of second set of natural frequency analysis for steel and composite

Fig 4.4 Comparision of third set of natural frequency analysis for steel and composite

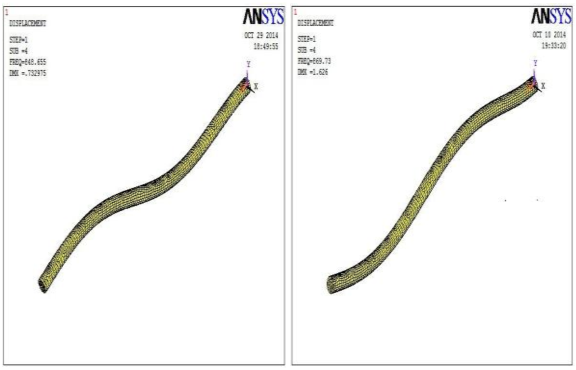

Fig 4.4 Comparision of fourth set of natural frequency analysis for steel and composite

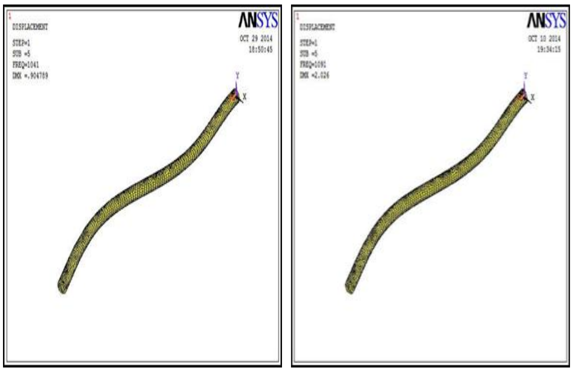

Fig 4.5 Comparision of fifth set of natural frequency analysis for steel and composite

Static analysis:

Table-4.1 Comparision Of Static Analysis

MATERIAL		HSC+HMC+KEVLAR+EPOXY	HSC+HMC+KEVLAR+EPOXY	HSC+HMC+KEVLAR+EPOXY	STEEL
ANALYSIS	ORIENTATION	0/40/-40/90/0	0/45/-45/90/0	0/50/-50/90/0	-
STATIC ANALYSIS/DISP VEC.SUM	DMX	0.002821	0.00286	0.002775	0.000466
	SMX	0.002821	0.00286	0.002775	0.000466
ROT VEC SUM	SMX	0.342375	0.342735	0.339896	0.099112
FIRST PRINCIPLE STRESS	SMN	-944308	-2810000	-734821	-4210000
	SMX	1920000000	1820000000	1890000000	2860000000
SECOND PRINCIPLE STRESS	SMN	-89700000	-442000000	-141000000	-158000000
	SMX	110000000	254000000	117000000	149000000
THIRD PRINCIPLE STRESS	SMN	-3750000000	-3210000000	-3110000000	-2730000000
	SMX	2360000	3290000	1910000	4340000
VON MISSES STRESS	SMX	4060000000	3440000000	3440000000	3320000000

From the above table we conclude that among three types of composite model the displacement vector sum has minimum value for 0/50/-50/90/0 orientation and its value is 83% higher than the steel material, Rotation vector sum has minimum value for 0/50/-50/90/0 orientation and its value is 70.84% higher than the steel material, 1st principle stress has minimum value for 0/45/-45/90/0 orientation and its value is 36.36% lower than the steel material, 2nd principle stress has minimum value for 0/40/-40/90/0 and its value is 26.17% lower than the steel material, 3rd principle stress has minimum value for 0/50/-50/90/0 orientation and its value is 55.99% lower than the steel material, Von misses stress has minimum for 0/45/-45/90/0, 0/50/-50/90/0 orientation and its value is 3.4% higher than the steel material.

Modal and buckling analysis:

Table-4.2 Comparision Of Modal And Buckling Analysis

MATERIAL		HSC+HMC+KEVLAR+EPOXY	HSC+HMC+KEVLAR+EPOXY	HSC+HMC+KEVLAR+EPOXY	STEEL
ANALYSIS	ORIENTATION	0/40/-40/90/0	0/45/-45/90/0	0/50/-50/90/0	-
MODEL ANALYSIS/ FIRST SET	DMX	1.951	1.955	1.958	0`.928298
	FREQ	104.262	104.194	104.478	73.816
SECOND SET	DMX	1.632	1.632	1.631	0.73139
	FREQ	286.501	287.265	288.045	266.954
THIRD SET	DMX	2.124	2.122	2.12	0.936901
	FREQ	440.212	442.479	446.139	391.165
FOURTH SET	DMX	1.626	1.626	1.625	0.732975
	FREQ	866.007	869.73	873.921	848.655
FIFTH SET	DMX	2.027	2.026	2.024	0.904789
	FREQ	1082	1091	1103	1041
BUCKLING ANALYSIS	DMX	0.028803	0.060457	0.023627	0.212935
	FREQ	27.287	27.212	24.01	60.09

(I) Model analysis

Natural frequency value of first set has maximum value for 0/50/-50/90/0 orientation and its value is 29.34% higher than the steel material, Natural frequency value of second set has maximum value for 0/50/-50/90/0 orientation and its value is 7.3% higher than the steel material, Natural frequency value of third set has maximum value for 0/50/-50/90/0 orientation and its value is 12.32% higher than the steel material,Natural frequency value of fourth set has maximum value for 0/50/-50/90/0 orientation and its value is 2.89% higher than the steel material, Natural frequency value of fifth set has maximum value for 0/50/-50/90/0 orientation and its value is 5.62% higher than the steel material,

(II) Buckling analysis

Buckling strength has maximum value for 0/40/-40/90/0 orientation and its value is 54.58% lower than the steel material. The results obtained by this analysis are highly coinciding with previous researchers.

V.CONCLUSION

In this paper comparison of drive shaft for steel and composite is carried out based on maximum deformation, maximum and minimum stresses induced in the shaft. Its design procedure is studied and along with finite element analysis some important parameters are obtained. The composite drive shaft made up of high strength carbon, high modulus carbon and Kevlar / epoxy multilayered composites has been designed. The replacement of composite materials has resulted in considerable amount of weight reduction when compared to conventional steel shaft. Also, the results reveal that the ply orientation of fibers has great influence on the static characteristics of the composite shafts

1) The usage of composite material has resulted in considerable amount of weight saving and the amount of weight reduction is nearly 79% when compared to conventional steel shaft.

2) The presented work was aimed to reduce the fuel consumption of the automobile in the particular or any machine, which employs drive shafts.

By taking into considerations the weight saving, deformation, shear stress induced and resonant Frequencies it is evident that hybrid of high strength carbon, high modulus carbon and Kevlar/Epoxy composite has the most encouraging properties to act as replacement for steel.

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